EFFECT OF CONCURRENT COGNITIVE TASK ON POSTURAL SWAY IN TYPE - II DIABETIC INDIVIDUALS WITH AND WITHOUT SENSORIMOTOR POLYNEUROPATHY

Dissertation submitted to The Tamilnadu Dr. M.G.R. Medical University towards partial fulfillment of the requirements of MASTER OF PHYSIOTHERAPY (Advanced PT in Neurology) Degree Programme.

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CERTIFICATE

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This is to certify that research work entitled **"EFFECT OF CONCURRENT COGNITIVE TASK ON POSTURAL SWAY IN TYPE- II DIABETIC INDIVIDUALS WITH AND WITHOUT SENSORIMOTOR POLYNEUROPATHY"** was carried out by the candidate bearing the **Register No: 27101612**, KMCH College of Physiotherapy, towards partial fulfillment of the requirements of the **Master of Physiotherapy (Advanced PT in Neurology)** degree course under The Tamil Nadu Dr. M.G.R. Medical University, Chennai-32.

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- Albert Einstein

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ABSTRACT

ABSTRACT

OBJECTIVE: Diabetic neuropathy is one of the serious microvascular complications of diabetes. Impaired sensation of lower limbs due to diabetic neuropathy can lead to unsteady posture and increases the risk of fall. The automaticity of postural control decreases with reduced sensory feedback. Dual task assessment detecting the proportion of attentional requirements may aid in early identification and prompt management of postural instabilities. The aim of the study was to identify the effect of concurrent cognitive task on postural sway in type II diabetic individuals with and without neuropathy. **STUDY DESIGN:** Comparative study design. **PARTICIPANTS:** 30 type II diabetic individuals satisfying the selection criteria were grouped into diabetic without neuropathy and diabetic neuropathy group based on Michigan Neuropathy Screening Instrument. **PROCEDURE:** Postural sway was measured in 8 different conditions with the individual standing on a firm surface with feet close together. The subjects performed four levels of cognitive task (no task, cognitive task I,II,III) in eyes open and closed condition. **OUTCOME MEASURE:** In each experimental condition postural sway was measured using sway meter for 30 secs. The peak to peak ant-post, med-lat sway was calculated manually from the recorded graph sheet. **RESULTS:** The results indicated that the concurrent cognitive tasks on standing produced same effect on sway as that of standing with no task. Even though mean differences existed between diabetic without neuropathy (AP = 19.8±7.2,ML = 19.8±7.23) and diabetic neuropathy group(AP = 22.1±8.73,ML = 23.8±11.5), it failed to elicit a statistical significance. **CONCLUSION:** The concurrent application of cognitive tasks on standing, showed no effect on the postural sway between diabetic without neuropathy and diabetic neuropathy group.

INTRODUCTION

1. INTRODUCTION

Diabetes Mellitus is a chronic disease that occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. Hyperglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes and over time leads to serious damage to many of the body's systems, especially the nerves and blood vessels – World Health Organization (WHO)[47]

The International Diabetes Federation estimates that there are over 300 million people around the world with diabetes. The number of diabetic people in India (2010) is approximately around 50, 768, 3004 which accounts for about 7.1% of the adult population. With this huge number of 50.8 million, the number of Indian Diabetic population is expected to increase further to reach 87 million (i.e., 8.4% of adult population) by 2030.

Diabetes mellitus can be classified into three categories as Type-1, Type-2 and Gestational diabetes. Type-1 has sudden onset of symptoms occurring at any age with the presence of auto-antibodies and also comparatively less prevalent, Whereas Type-2 has a gradual onset of symptoms usually occurring at adult hood and is more prevalent. Gestational diabetes occurs in about 2 to 5% of all pregnancies and it resembles type-2 but disappears or improves after delivery.

According to WHO(2006), the criteria for diagnosing type-2 diabetes requires a fasting plasma glucose $\geq$ 7.0 mmol/l (126mg/dl) or increased plasma glucose 2 hours after ingestion of 75g oral glucose load $\geq$ 11.1 mmol/l(200 mg/dl) on single occasion with symptoms or on two occasions without symptoms.[47] Type-2 diabetes is commonly diagnosed after the age of 40 years but may occur at an earlier age due to changing life style factors and genetics. The manifestation of diabetes can present itself either as insulin resistance or relative insulin deficiency.

Hyperglycemia is a serious problem in diabetes mellitus. With higher magnitude and longer duration of hyperglycemia, the risk of developing various complications of diabetes mellitus also increases. Poor control of hyperglycemia along with additional risk factors like hypertension, dislipidemia, obesity and insulin resistance may lead to various macro and microvascular complications including diabetic peripheral neuropathy[46].

Diabetic peripheral neuropathy occurs mainly due to the nerve damage caused by nerve ischemia and also compression of small nerve fibers by enlarged water saturated Schwann cells. Sensory motor polyneuropathy is a type of peripheral neuropathy which has both positive (burning and shooting pain) and negative features (weakness, numbness) with distal symmetrical "glove and stocking presentation".[9] It mainly affects the lower limbs producing considerable morbidity, mortality and diminished quality of life.

The maintenance of upright posture by an individual depends on the central processing of multiple afferent inputs from somatosensory, vestibular and visual systems.[13] Among them, somatosensory system provides information about the posture with reference to supporting surface. Hence standing on a more stable, firm surface makes the postural control mechanisms of the body to depend on the somatosensory system.[12]

The distal symmetrical somatosensory loss after diabetic polyneuropathy reduces the sensory information reaching the higher centre. Poor sensory perception affects the automatic postural control responses of the body. This creates unsteadiness in the posture with increase in the postural sway which is the displacement of centre of gravity within the base of support. The larger the sway path, the greater is the postural unsteadiness which may increase the falls risk.[39]

Postural control has long been considered an automatic component of human motor control requiring little or no cognitive processing.[26] A feed forward control of posture with a prior knowledge and expectation has a profound influence on the timing of such anticipatory postural adjustments.[13] The use of such knowledge implies at least some cognitive processing for postural control in healthy subjects. In the presence of diabeteic sensorimotor polyneuropathy, the proportion of automatic postural adjustments decline which is compensated by a more attention demanding postural control strategy.

Dual task can be used to examine the proportion of automatic and attention demanding components of postural control mechanism. Dual task consists of a primary task and a secondary task. Among the two tasks, priority should be given to the primary task. On adding the secondary task to it, the interference between the two tasks is analyzed. Primary and secondary task can be either motor or cognitive. Motor tasks include activities like walking, standing. Cognitive tasks include activities which demands mental processing skills like attention, memory and execution.

When a cognitive task is given to a standing individual, central nervous system uses greater proportion of its information processing capacity to process the cognitive task and a very small capacity is used to maintain the posture. When the posture itself is attention demanding as in diabetic neuropathy with loss of sensory feedback, then addition of a cognitive task to it may have a negative influence on either one or both activities simultaneously.

1.1 THEORITICAL DEFINITIONS

- **Dual tasking:** performing two tasks simultaneously
- **Concurrent cognitive task:** A simultaneously performed cognitive task which demands mental processing abilities.
- **Dual task paradigm:** defined as the one in which subject performs two distinctly different tasks and the investigator assess the degree to which the two tasks interfere with each other.
- **Dual task interference:** the decline in performance of one or two tasks when performing two tasks concurrently.[15]
- **Neurophysiological theories of Dual task interference**
    - **The capacity or resource sharing theory:** based on limited attentional resources assumption. When performing two tasks simultaneously, the resources available must be divided equally between two tasks. A competition exists between the two tasks to gain processing ability skill in performance. According to the requirement of the task the resource available can be allocated. The proportion of attention available to the performed task is based on the difficulty, familiarity and priority. Dual task interference results when the need exceeds the resource limit, causing decline in performance of one or both tasks.
    - **The filter or bottleneck theory:** refers to the serial processing of information when multiple inputs are presented in limited information processing situation. The bottleneck or filter permits single information at a time for processing blocking the rest.
    - **Crosstalk theory:** It is the communication between the sensory information and cognitive processing. The theory was explained based on the existing similarity between tasks. When two similar tasks are performed simultaneously, they share common pathway leading to a simple information processing. The performance of two dissimilar tasks may activate different brain areas for each task, causing complex information processing which may interrupt and induce interference between two tasks.

[redacted]ariations In Dual Task Activities:

The types of dual tasks commonly employed in assessing dual task interference[10] are

- Working memory tasks
    - E.g.: Counting backwards
- Verbal fluency tasks
    - E.g.: Naming the items starting with any given letter
- Motor tasks
    - E.g.: Carrying a tray
- Auditory task
    - E.g.: listening the words and repeating them
- Visual task
    - E.g.: Searching for a visual target
- Other executive function tests.

1.2. NEED FOR THE STUDY

Type -2 diabetes mellitus has high incidence and prevalence among adult population due to changing life style factors. Persistent hyperglycemia is a life threatening issue, lack of proper glycemic control can lead to various microvascular complications. Diabetic sensorimotor polyneuropathy is one such complication commonly involving both the lower limbs. Diminished sensation caused by distal symmetrical involvement of diabetic sensory motor polyneuropathy may lead to altered postural control mechanisms.

Diabetic neuropathic individuals have loss of sensory feedback from the limbs about the supporting surface which causes significant postural instability. This postural unsteadiness can adversely affect the individuals quality of life by increasing the risk of falls. But, there is also no strong evidence to exclude the effects of diabetes itself from the factors increasing postural sway.[1] The pathological process of the diabetes along with the sensory impairment caused by neuropathy may have a combined effect on postural sway. When diabetic subjects with neuropathy and diabetic subjects without neuropathy are compared, the pathological process of the disease between the groups remains the same. This helps to discriminate the role of added neuropathic features of diabetic neuropathy group in increasing the postural sway.

Shumway Cook and Woollacott M (2000), reported that with reduced sensory feedback, increased attentional demands are needed to maintain a stable posture[39]. To a task with compromised automaticity, addition of another attention demanding task may challenge the performance of either one or both the tasks. Hence dual task assessments are emphasized in analyzing the level of automaticity in postural control and gait.

When the postural control mechanisms of both the groups are challenged with a cognitive task, the proportion of automaticity in maintaining the posture can be determined. With the difficulty in dividing attention between two tasks, the individuals lose control over posture, thereby risk of falls increases. Early identification and prompt intervention for postural instability may improve the quality of life of the individuals. Also there is no enough evidence to address the impact of a concurrent cognitive task on postural sway in diabetic individuals with and without neuropathy.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 POSTURAL CONTROL MECHANISMS

- **Fay.B. Horak (2006)** conceptualized physiological and biomechanical aspects of orientation and equilibrium of posture in the context of neural control. Postural system is a complex system involving multiple sensory-motor process rather a single system concerned with righting and equilibrium reflexes. The article described that the feed forward adjustments based on one's previous exposure to the situation may aid in the maintenance of posture when a volitional activity of limb was superimposed on it. The author declared that the difficulty level of the task performed and capacity of individual's postural control system determines the amount of attention required to maintain the posture. Any pathological process affecting the postural control systems may in turn disrupt the normal
  postural stability[13]

2.2 POSTURAL SWAY AND DIABETIC PERIPHERAL NEUROPATHY

- **Cedrick T. Bonnet et al., (2011)** done a review to evaluate whether peripheral neuropathy was the only reason that accounts for increased sway in diabetic population. The study reviewed 26 articles which compared Centre of Pressure sway (from force platform) and body sway (through markers) among the control and diabetic neuropathy group. In the analyzed articles, diabetic neuropathic population exhibited increased sway than control on a firm surface with eyes open.

  When a foam surface was used to attenuate the sensory information of control and diabetic neuropathy group, the latter showed increased sway where they were expected to sway equally to that of control group. Apart from the loss of sensory feedback, the author emphasized to address visual problems and incoordination of posture among the reasons for the sway. The review also highlights the effectiveness of hand facilitators in reducing sway compared to feet facilitation techniques.[2]
- **Cedrick Bonnet et al., (2009)** reviewed 28 articles to detect the extent of postural sway variations among diabetic with and without neuropathy and healthy control subjects. The

objective of the review was to analyze the level of evidence available to support diabetes itself as a causative factor of postural sway. Majority of the studies mentioned diabetic sensory neuropathy as the primary source for increased sway. The author reported the lack of strong evidence for excluding other causes like diabetic(itself), motor, central and autonomic neuropathies in magnifying the postural sway[1]

- **Emam AA (2009)** analyzed the postural stability of type II diabetic people using posturography and also correlated postural stability and glycemic control. The study included 54 diabetic subjects with neuropathy and 18 diabetic subjects without neuropathy. The diabetic neuropathy group was further divided into 2 groups based on the glycosylated hemoglobin values (HbA1c) as 24 controlled diabetics (HbA1c ≤ 7) and 30 uncontrolled diabetics (HbA1c >7). The sensory organization test was done in eyes open and eyes closed and with sway referenced vision condition on fixed and moving platform. The composite equilibrium score was significantly less in the neuropathic group when compared to the diabetic group without neuropathy. The HbA1c value had a negative correlation($r = -0.395$) with poor glycemic control and not with good control.[11]

- **Fay B. Horak (2002)** compared the effects of different methods of sway referencing the surface among the diabetic individuals with profound neuropathy and healthy control subjects to identify the type of sensory feedback lost in sensory neuropathy. The sway referencing procedure blocked the sensory information with dorsiflexion and plantar flexion rotation of the surface in relation to anterior-posterior movement of ankle angle, centre of pressure, centre of body mass.

  Diabetic neuropathic individuals exhibited increased sway on firm surface than on sway referenced surface indicating the less role of sway referencing surface in blocking the sensory information which is already affected lost. The healthy control group showed greater sway with sway referencing surface when compared to neuropathic subjects on a firm surface, indicating the greater influence of sway referencing surface in blocking the information than sensory disruption due to neuropathy.[12]

- **Yamamoto R et al., (2001)** evaluated the relationship between postural sway and diabetic neuropathy using posturography in type II diabetic individuals. The subjects were age matched including 123 diabetic subjects without neuropathy and 32 diabetic subjects with neuropathy and 55 normal subjects. The results revealed significant correlation between posturographic and electrophysiological parameters. The sway envelope area was larger in neuropathy group than in diabetic and healthy control subjects. The individuals with diabetic neuropathy exhibited obvious difficulty in maintaining stable posture.[36]

- **Corriveau et al., (2000)** compared the balance parameters of diabetic neuropathic elderly subjects with age matched controls. The distance between the centre of mass and centre of pressure was measure using posturography in quiet standing position with eyes open and eyes closed conditions for 15 elderly diabetic neuropathic subjects and 15 healthy elderly subjects. The distance was significantly larger in both Anterior-posterior and Medial-Lateral directions for diabetic neuropathic group than healthy individuals. The magnitude of the sway increase with vision occluded condition.[18]
- **Oppenheim et al., (1999)** compared the posturographic performances of three group of diabetic neuropathic individuals (28) with severe (8), moderate (12) and no neuropathy (8) with 30 healthy control subjects and with 52 unhealthy control subjects [parkinsons stage II (14), Vestibular pathology (19), brain damage (13) and whiplash (7)]. The performance was analyzed while standing on foam surface with eyes closed and head turning conditions. Diabetic patients with neuropathy (moderate and severe) were comparatively less stable than normals, but exhibited equal instability as that of unhealthy controls. Sway analysis with head turns may help to discriminate diabetic neuropathy form other disorders causing postural instability[32]
- **Luigui Uccioli et al., (1995)** evaluated the impact of peripheral neuropathy on postural sway among subjects with diabetes mellitus. The study includes age matched subjects with 10 diabetic neuropathic subjects, 23 diabetic subjects, and 21 control subjects. The postural sway was analyzed using posturography. The sway surface was larger in diabetic neuropathic group than other group. The results showed a direct correlation between changes in nerve conduction velocity and posturographic parameters. Diabetic neuropathic subjects demonstrated significant features of instability in posture than the controls.[24]
- **Simoneau et al., (1994)** examined the effect of distal symmetrical sensory loss related to diabetic peripheral neuropathy on postural stability. The study included 51 subjects – 17 with diabetic neuropathy, 17 diabetic subjects without neuropathy and 17 healthy subjects.

Postural stability was analyzed using force platform on a quite standing position. Sensory, physical and functional examinations were also conducted and the measures were quantified. The results indicated a significant postural unsteadiness among diabetic neuropathic than with diabetes alone. The diabetic neuropathic were 66 to 117% highly instable than healthy control subjects.[40]

2.3 IMPACT OF DUAL TASK ON POSTURAL SWAY

- **A.Zijlstra et al.,(2008)** reviewed 19 articles out of which 14 studies had 60 subjects. The objective of the review to identify an effective balance assessment tool for the development of preventive programs for older people and also to evaluate the sensitivity of dual task and single task balance assessment in predicting falls. Most of the articles reviewed showed a limited comparison between single and dual task. The articles exhibited less sensitivity of 55% for dual task assessment for detecting only a part of fallers who need increased attention to maintain posture. The author reported that including a dual task assessment may be a better predictive to fall than a single task assessment alone.[48]
- **Janina .M. Prado et al.,(2007)** analyzed the changes in postural sway among young and elderly adults while performing a dual task. The study included 12 elderly (65-75 years) and 12 young (22-39 years). The participants performed dual tasks while measuring the postural sway simultaneously with force platform. The dual tasks are given in the form of visual tasks – attending to a target visual stimulus (blank Vs search target, distance of the target). Both groups showed increased sway in the mediolateral direction in eyes closed than in eyes open. Anteroposterior changes were observed only in elderly group. The study concludes that visual dual task may not increase the sway.[21]
- **Oliver Huxhold et al.,(2006)** examined the U- shaped relationship between efficient postural control and simultaneous cognitive demands among 41 adult participants. The author experimented 3 single task conditions in sitting and 5 experimental cognitive tasks with participants standing on force platform. The older adults exhibited lower cognitive and lesser postural control than younger ones in both dual and single task conditions. The

cognitive demand among the older individuals followed the expected U shaped relationship - High and low cognitive task induces high level of arousal which in turn stimulates the postural control mechanisms.[31]

- **Geraldine L. Pellecchia (2003)** The study was done on 20 healthy individuals to determine whether postural sway differed significantly with the difficulty of the cognitive task presented simultaneously. The sway measures were taken in 4 different experimental conditions with the individual standing on a foam surface placed over a force plate. The cognitive tasks were given with graded difficulty. The results showed the increase in postural sway with increasing difficulty of the task.[35]
- **Shumway-Cook et al**., **(2002)** reviewed articles to explore the influence of cognitive processing in gait and posture. The authors concluded that the amount of attention required in maintaining balance varied depending upon the difficulty level and the type of superimposed secondary task. The Author recommended the use of dual task paradigms in the routine clinical assessment to reveal the effect of disease and also to determine the ability of the individual to alternate the attention to maintain posture. This will add to the sensitivity of the assessment procedure to detect falls.[26]
- **Sandra G Brauer (2000)** studied 13 elderly subjects with balance deficits to analyze the effect of attention demanding task in the recovering from postural displacements. The subjects showed increased time and were less efficient to correct posture in dual tasking conditions, where as healthy subjects exhibited an efficient pattern and correct displacements without effort.[37]
- **Shumway Cook et al.,(2000),** examined the effect of different sensory conditions on the postural steadiness while performing a simultaneous cognitive task. The study included 18 young subjects, 18 healthy elderly subjects and 18 subjects with balance deficit. Elderly individuals showed difficulty in maintaining balance with incorporation of another task. The study suggested that lack of sensory information may demand more cognitive processing to maintain posture. Multitasking environment may increase the risk of fall among the individuals with sensory deficit.[39]
- **Paul, L et al., (2009)** in the study on the effect of cognitive or motor task on the gait parameters of those with diabetes, with and without neuropathy. The study included 15 diabetic neuropathic subjects and 15 diabetic subjects without neuropathy. The author

analyzed the temporal and spatial characters of gait with a Gait Rite walk way. The participants initially performed single task walking, followed by walking with a simultaneous motor task and then with a simultaneous cognitive task. The gait parameters of the diabetic neuropathy group differed significantly from that of diabetic group. The subjects with DPN were less able to divide and divert their attention which lead to a deterioration of the gait [34]

2.4 POSTURAL SWAY MEASUREMENT

- **Daina L sturnieks et al., (2011)** analyzed the validity of sway meter measurements by relating it with the measurement of a force platform. The postural sway of the subjects was measured simultaneously with a force plate and a sway meter. The measurements were taken on a firm and foam surface with eyes open and eyes closed conditions. The study included 29 elderly subjects and 11 young subjects. The sway meter was reliable across trails with interclass coefficient of 0.654 and 0.944. The author found it to be a reliable measuring tool and concluded that it was able to differentiate various sensory conditions experimented.[7]
- **Sivakumar Ramachandran et al.,(2011)** measured postural sway with the use of sway meter to obtain normative data in healthy subjects. The study included 60 students between the age group of 20 and 30 years. The author measured the sway in anterior, posterior, medial and lateral directions. The author commented it to be a reliable and cost effective tool when compared to the sophisticated methods of measuring posture[41].
- **Stephen R Lord et al.,(2003)** in a study emphasizing fall assessment profile to predict the risk of falls , recommended the use of sway meter to measure anterior – posterior and medial-lateral displacements. The study also detailed the features of the instrument recording the postural displacements at the waist level[43].

2.5 MICHIGAN NEUROPATHY SCREENING INSTRUMENT

- **Ugoya So et al.,(2006)** studied the diabetic population cross sectional for the frequency of occurrence of diabetic neuropathy . The study also analyzed variations and the severity level of the condition among the diagnosed population. The study used Michigan screening instrument to screen the diabetic population for detecting neuropathic symptoms. The author described it as a useful and simple tool with the specificity and sensitivity 95% and 80%.[44]

- **Ali Moghtaderi et al.,(2005)** in order to validate Michigan neuropathy screening instrument for identifying diabetic neuropathy, examined 176 subjects with type 2 diabetes. The author confirmed it as an accurate screening tool which is 65% sensitive and 83% specific for a score of 2.[30]
- **Feld man EL et al., (1994)** designed and analyzed the effectiveness of the assessment for diagnosing neuropathic symptoms among type1 and type II diabetic population. The author used a screening instrument along with a questionnaire for preliminary diagnosis, which was then followed by assessment with Michigan diabetic neuropathy score. The results of the study showed that 28 subjects with a score 2 on Michigan neuropathy Screening Instrument (MNSI) had neuropathy. Hence the author confirmed the effectiveness of the tool to screen neuropathy among diabetic population[14].

2.6 MINI COG ASSESSMENT

- **Soo Borson et al., (2006)** done study to determine the effectiveness of minicog tool in detecting cognitive impairment among general population in the community. The study was conducted on a heterogeneous population including the individuals differing in social and demographic characteristics. The dissimilarities in educational status, language spoken, had no effect on the performance of minicog test. Hence mini cog can be easily administered across different group of population.[5]
- **Soo Borson et al.,(2003)** used minicog to screen the dementia in the elderly people. The author also compared minicog tool with mini mental state examination, to analyze the variations in sensitivity, specificity and the duration for administering the test between the two. Minicog had a similar specificity (76%) and sensitivity (89%) like that of Mini Mental Status Examination (MMSE) which was 79% specific and 89% sensitive. The time taken to administer it was very small compared to MMSE (minicog :2-4 mins; MMSE;5-12mins.[4]

AIMS & OBJECTIVES

3. AIMS AND OBJECTIVES

3.1 AIM OF THE STUDY:

- To identify the effect of concurrent cognitive task on postural sway in type II diabetic individuals with and without sensorimotor polyneuropathy

3.2 OBJECTIVES:

- To identify the effect of concurrent cognitive task on postural sway in type II diabetic individuals without sensorimotor polyneuropathy
- To identify the effect of concurrent cognitive task on postural sway in type II diabetic individuals with sensorimotor polyneuropathy
- To compare the effects of concurrent cognitive task on postural sway between both the groups

MATERIALS & METHODOLOGY

4. MATERIALS AND METHODOLOGY

- **4.1. Study Design:** Comparative Study
- **4.2. Sampling Technique**: Purposive Sampling
- **4.3. Sample Population:**
    - Diabetic neuropathy group: 15 subjects
    - Diabetic without neuropathy group: 15 subjects
- **4.4. Study Setting:** Kovai Medical Centre and Hospital, Coimbatore.
- **4.5. Criteria For Selection**
    - **4.5.1. Inclusion Criteria**
        - Individuals with Type 2 diabetes for more than 3 years
        - Both the sexes
        - Body mass index >18.5
        - Age between 50 and 75
        - With normal corrected vision
        - Individuals satisfying all three components of minicog test
    - **4.5.2. Exclusion Criteria**
        - Individuals with diabetic feet ulcers
        - Individuals with vestibular problems
        - Individuals with musculoskeletal pain
        - Individuals with peripheral vascular disorder
        - Individuals with nephropathy
        - Individuals with history of neurological dysfunction other than diabetic neuropathy
        - Individuals with history of ankle sprain or ankle stiffness
        - Individuals with unstable cardiovascular disease
    - **4.5.3. Grouping Criteria**
        - Individuals who score > 2 on Michigan screening instrument for neuropathy are included into diabetic neuropathy group

- Individuals who score $\leq$ 2 on Michigan screening instrument for neuropathy are included into diabetic without neuropathy group .

4.6. Hypothesis:

4.6.1. Null Hypothesis

- $H_{01:}$ There is no significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic without neuropathy group
- H_{02}: There is no significant effect of cognitive task on Medial- Lateral sway with eyes open condition among diabetic without neuropathy group
- $H_{03:}$ There is no significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic neuropathy group
- H_{04}: There is no significant effect of cognitive task on Medial- Lateral sway with eyes open condition among diabetic neuropathy group
- $H_{05:}$ There is no significant effect of cognitive task on Anterior-posterior sway in eyes closed condition among diabetic without neuropathy group
- $H_{06:}$ There is no significant effect of cognitive task on Medial- Lateral sway with eyes closed condition among diabetic without neuropathy group
- $H_{07:}$ There is no significant effect of cognitive task on Anterior-posterior sway with eyes closed condition among diabetic neuropathy group
- H_{08}: There is no significant effect of cognitive task on Medial- Lateral sway with eyes closed condition among diabetic neuropathy group
- $H_{09:}$ There is no significant effect of cognitive task on Anterior-posterior sway with eyes open condition between diabetic without neuropathy group and diabetic neuropathy group
- $H_{010:}$ There is no significant effect of cognitive task on Medial- Lateral sway in eyes open between diabetic without neuropathy group and diabetic neuropathy group
- $H_{011:}$ There is no significant effect of cognitive task on Anterior-posterior sway with eyes closed condition between diabetic without diabetic neuropathy group and diabetic neuropathy group

- $H_{012:}$ There is no significant effect of cognitive task on Medial- Lateral sway with eyes closed condition between diabetic without diabetic neuropathy group and diabetic neuropathy group

4.6.2. Alternate Hypothesis

- $H_{A1:}$ There is a significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic without neuropathy group
- H_{A2}: There is a significant effect of cognitive task on Medial- Lateral sway with eyes open condition among diabetic without neuropathy group
- $H_{A3:}$ There is a significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic neuropathy group
- H_{A4}: There is a significant effect of cognitive task on Medial- Lateral sway with eyes open condition among diabetic neuropathy group
- $H_{A5:}$ There is a significant effect of cognitive task on Anterior-posterior sway in eyes closed condition among diabetic without neuropathy group
- $H_{A6:}$ There is a significant effect of cognitive task on Medial- Lateral sway with eyes closed condition among diabetic without neuropathy group
- $H_{A7:}$ There is a significant effect of cognitive task on Anterior-posterior sway with eyes closed condition among diabetic neuropathy group
- H_{A8}: There is a significant effect of cognitive task on Medial- Lateral sway with eyes closed condition among diabetic neuropathy group
- $H_{A9:}$ There is a significant effect of cognitive task on Anterior-posterior sway with eyes open condition between diabetic without neuropathy group and diabetic neuropathy group
- $H_{A10:}$ There is a significant effect of cognitive task on Medial- Lateral sway in eyes open between diabetic without neuropathy group and diabetic neuropathy group
- $H_{A11:}$ There is a significant effect of cognitive task on Anterior-posterior sway with eyes closed condition between diabetic without diabetic neuropathy group and diabetic neuropathy group

- $H_{A12:}$ There is a significant effect of cognitive task on Medial- Lateral sway with eyes closed condition between diabetic without diabetic neuropathy group and diabetic neuropathy group

- **4.7. Study Method:**

✓ 4.7.1. Procedure:

Totally 30 type II diabetic subjects satisfying the selection criteria were recruited for the study. All participants were asked to sign the informed consent for confirming their participation in the study. The demographic data about the duration and control of diabetes were collected from all the selected subjects. All individuals were screened for neuropathic symptoms using Michigan neuropathy screening instrument and based on the scores they were grouped into diabetic without neuropathy group (≤ 2) and diabetic neuropathy group(>2). Participants of both the group were screened for cognitive impairment before commencing the sway measurement. Instructions about the sway measurement and task performance were detailed to the individual in sitting position. If needed trials of cognitive task were given to the individual.

✓ 4.7.2. Postural sway measurement:

Postural Sway was measured in 8 different experimental conditions with the individual standing on a firm surface with feet close together. All the tasks were measured with eyes open and eyes closed conditions.

- Standing with No Cognitive task - eyes open & closed
- Standing with Cognitive Task I - eyes open & closed
- Standing with Cognitive Task II - eyes open & closed
- Standing with Cognitive Task III -eyes open & closed

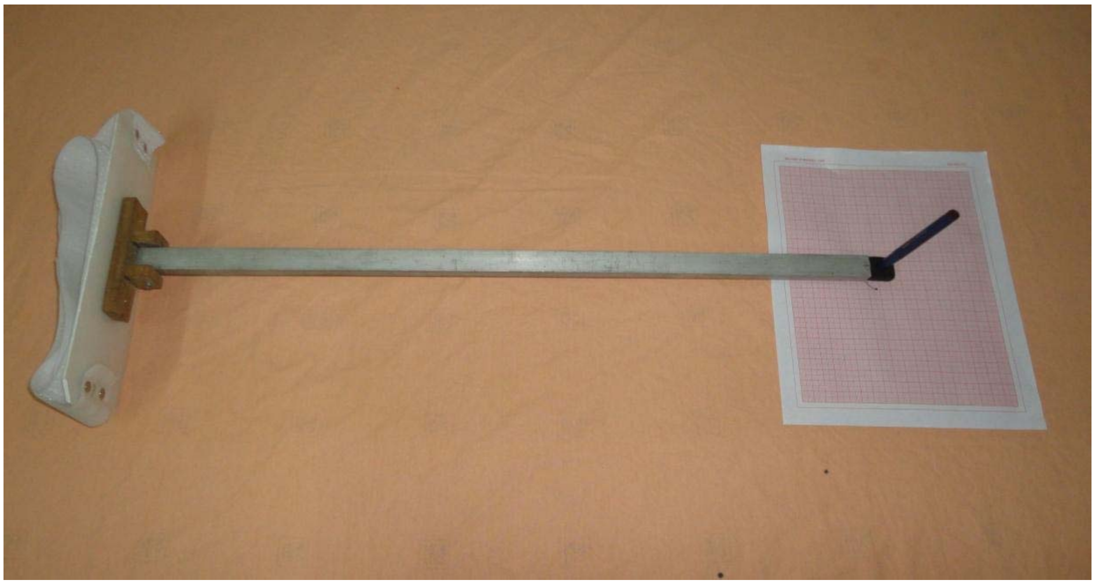
The sway was measured in each experimental condition using sway meter for 30 seconds. No rest was given between tasks. Totally 8 measurements were obtained from different testing condition. The peak to peak anterior- posterior sway, medial-lateral sway were calculated manually in millimeters from the sway recorded graph sheet

- ✓ **4.7.3. Tasks performed** :
    - **Postural Task:** Standing with feet close together
    - **Concurrent Cognitive Task:** 3 types of cognitive task
        - **Cognitive Task I:** In this task, a set of 5 paired digits were given to the individuals sequentially. The individuals were asked to reverse the paired digits and name it. E.g. if „3” and „4” were given, it should be reversed as „43”
        - **Cognitive Task II:** In this task, again a set of 5 paired digits were given sequentially. The individuals were asked to classify the digit as either below 50 or above 50. E.g., if „4” and „5” were given, it should be classified as below 50
        - **Cognitive Task III:** The individuals were asked to retrieve the 3 words which were given to them during the assessment session. Same words were given all the participants.

For cognitive tasks I and II, 5 set of numbers were given through recorded audio from the mobile phone at regular intervals within 30 seconds of sway measurement and for the cognitive task III , 30 seconds were given to retrieve the words. The individuals were instructed about the task in sitting position and trials were given if needed.

- **4.8. Measurement Tool:**
    - **5.8.1 Postural Sway Meter**: It records the displacement of the Centre of gravity in the horizontal plane at the Posterior superior iliac spine level. It consists of a rod extending horizontally with a pen placed vertically at one end. The other end of the rod is attached to a rigid plate fixed at the waist level of the patient by a firm strap. The pen records the sway of the patient on the graph sheet which is placed on a table of adjustable height.

SWAY METER



MATERIALS USED

HEIGHT ADJUSTABLE TABLE

SWAY MEASUREMENT WITH EYES OPEN

SWAY MEASUREMENT WITH EYES CLOSED

4.9. Statistical Analysis

- **4.9.1. ONE WAY ANOVA**

Source of variation	Sum of square (SS)	Degrees of freedom	Mean squares (MS)	F-ratio
Between samples	$n_1 (x_1 - x)^2 + ...$ $n_k(x_k - x)^2 + ...$	$k - 1$	$\frac{\text{SS between}}{k - 1}$	F=MSC/ MSE i.e., $\frac{\text{MS between}}{\text{MS within}}$
Within samples	$\Sigma(x_1 - x_1)^2 + ...$ $\Sigma(x_k - x_k)^2 + ...$	$n - k$	$\frac{\text{SS within}}{n - k}$	

MSC= mean sum of square between column, MSE= mean sum of square with in column.

- **4.9.2. TWO WAY ANOVA**

Source of variation	SS(Sum of squares)	I(Degrees of freedom)	MS(Mean square)	Variance (F-Ratio)
Between Samples	SSC	C-1	MSC=SSC/C-1	MSC/MSE
Between Rows	SSR	r-1	MSR=SSR/(r-1)	MSR/MSE
Residual of Error	SSE	(c-1) (r-1)	MSE=SSE/(r-1) (c-1)	
Total	SST	n-1		

MSC= mean sum of square between column, MSE= mean sum of square with in column

DATA PRESENTATION

5. DATA PRESENTATION

5.1. DEMOGRAPHIC DATA

Table 5.1.1.: Demographic data of the participants

S.no	Demographic variables		Diabetic without Neuropathy group	Diabetic Neuropathy group
1.	Gender (% of subjects)	Males	7 (46.7%)	8 (53.3%)
		Females	8 (53.3%)	7 (46.7%)
2.	Age (mean ± S.D)	Males	55.28± 9.63	58.0±8.5
		Females	49.37±4.3	50.57±8.3
3.	BMI (mean ± S.D)	Males	25.05±3.32	25.28±2.92
		Females	24.25±2.91	23.74±3.49
4.	Duration of diabetes (mean ± S.D)		6.8±4.37	7.4±4.7
5.	Michigan screening neuropathic instrument Score (mean ± S.D)		1.8±0.56	4.56±0.77
6.	Control of diabetes (No of subjects)	controlled	14	12
		uncontrolled	1	3

5.2 ONE WAY ANOVA

Table 5.2.1: Anterior-posterior sway with Eyes open condition among Diabetic without neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	149	3	49.667	1.349	2.70
Within samples	2016.6	56	36.814		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.1: Anterior-posterior sway with Eyes open condition among Diabetic without neuropathy group

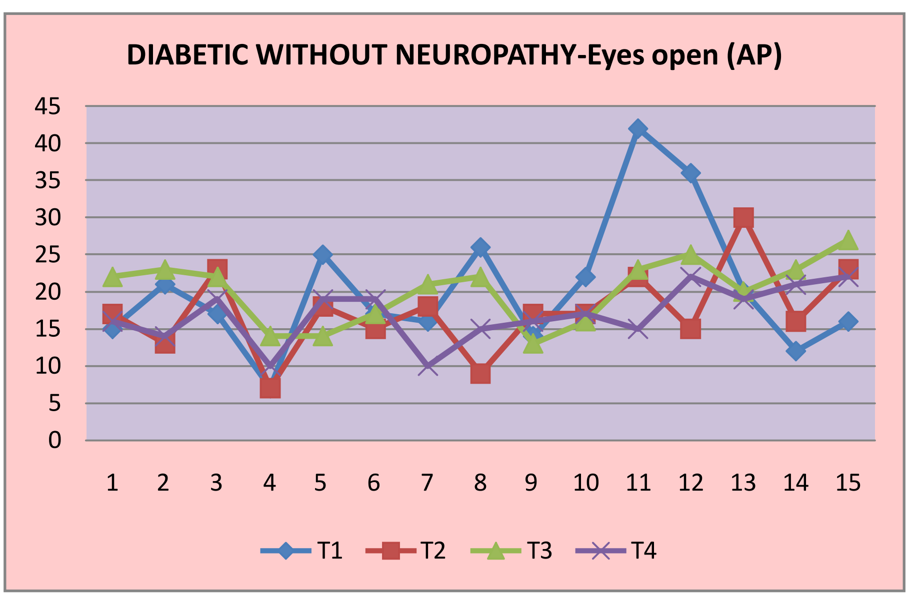


Table 5.2.2: Anterior-posterior sway with Eyes open condition for Diabetic neuropathy group

<table>
<tr><th>Source of variation</th><th>Sum of squares (SS)</th><th>Degrees of freedom</th><th>Mean squares (MS)</th><th>Calculated F – ratio</th><th>Table F- ratio</th></tr>
<tr><td>Between samples</td><td>122.05</td><td>3</td><td>40.683</td><td rowspan="2">0.863</td><td rowspan="2">2.70</td></tr>
<tr><td>Within samples</td><td>2604.13</td><td>56</td><td>47.145</td></tr>
<tr><td colspan="3">P value & Significance level</td><td colspan="3">P Value > 0.05, Not significant</td></tr>
</table>

Graph 5.2: Anterior-posterior sway with Eyes open condition among Diabetic neuropathy group

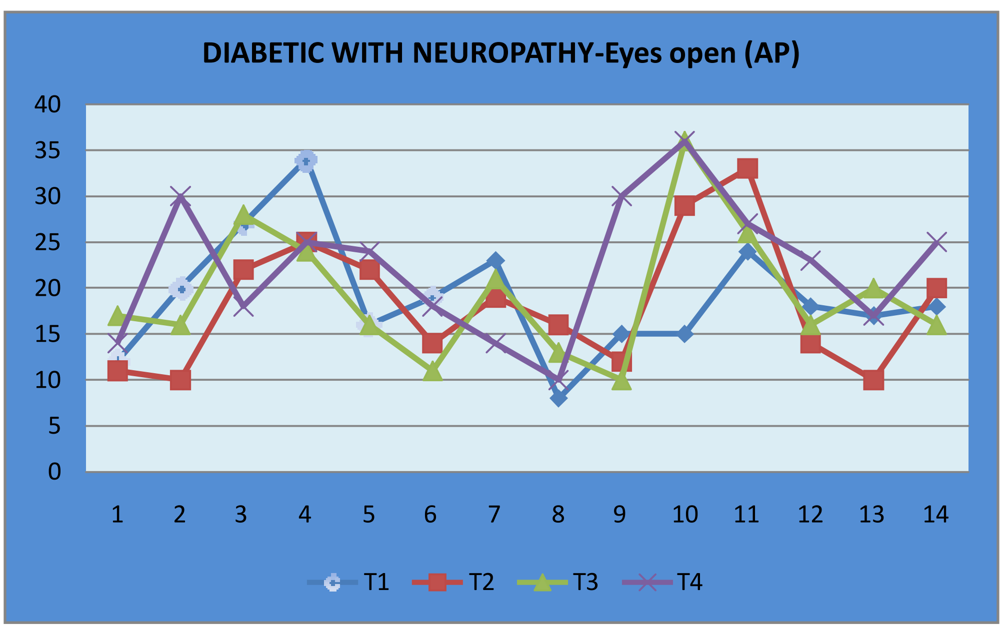


Table 5.2.3: Medial-Lateral sway with Eyes open condition among Diabetic without neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	187.2	3	62.4	1.219	2.70
Within samples	2866.53	56	51.18		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.3: Medial-Lateral sway with Eyes open condition among Diabetic without neuropathy group

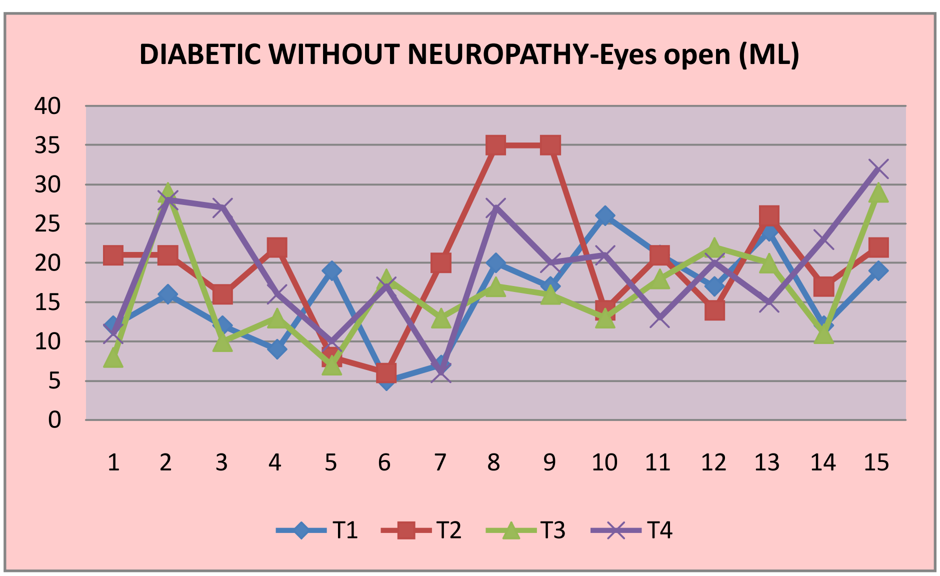


Table 5.2.4: Medial-Lateral sway with Eyes open condition among Diabetic neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between Samples	361.91	3	120.63	1.142	2.70
Within samples	5916.93	56	105.6		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.4: Medial-Lateral sway with Eyes open condition among Diabetic neuropathy group

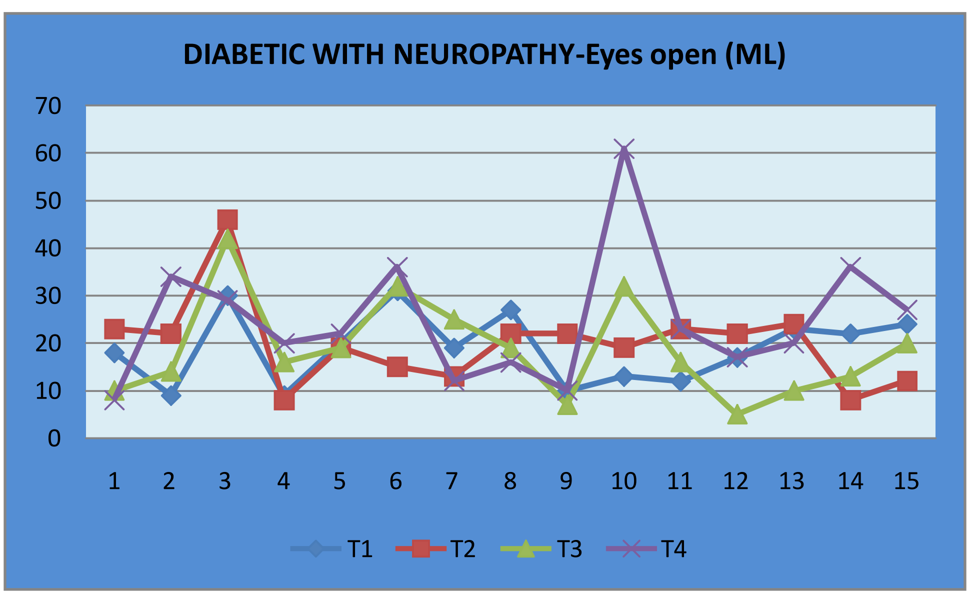


Table 5.2.5: Anterior-posterior sway with Eyes closed condition among diabetic without neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	0.183	3	0.61	0.001	2.70
Within samples	3654	56	62.25		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.5: Anterior-posterior sway with Eyes closed condition among diabetic without neuropathy group

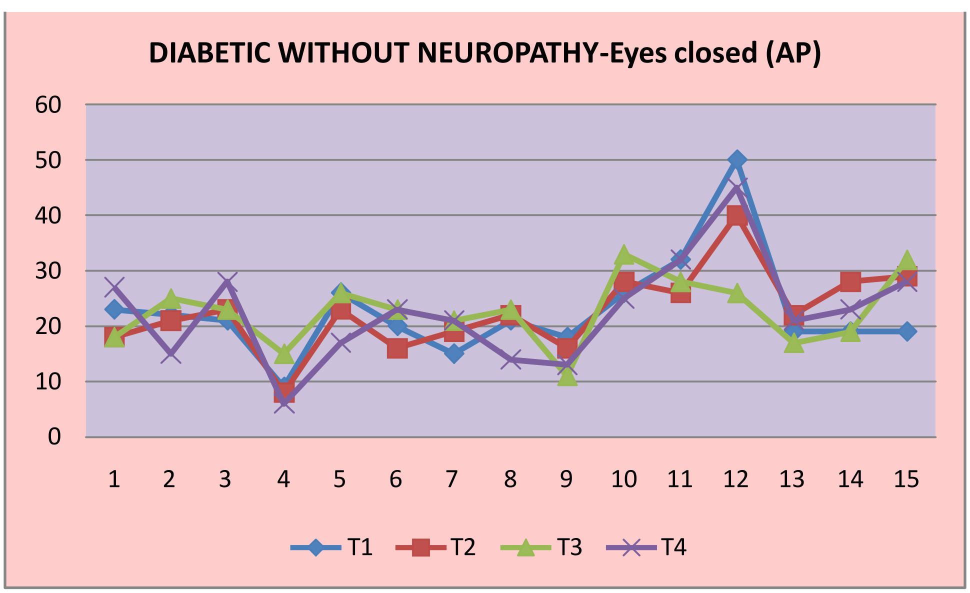


Table 5.2.6: Anterior-posterior sway with Eyes closed condition among Diabetic neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	57.667	3	19.22	0.197	2.70
Within samples	5455.067	56	97.412		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.6: Anterior-posterior sway with Eyes closed condition among Diabetic neuropathy group

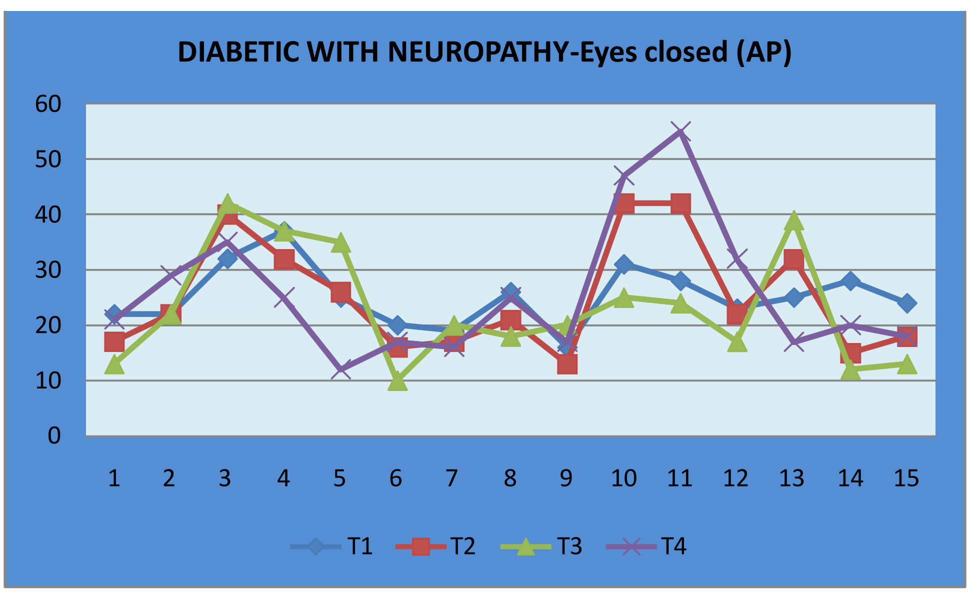


Table 5.2.7: Medial-Lateral sway with Eyes closed condition among Diabetic without neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	116.133	3	38.711	0.858	2.70
Within samples	2625.6	56	45.1		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.7: Medial-Lateral sway with Eyes closed condition among Diabetic neuropathy group

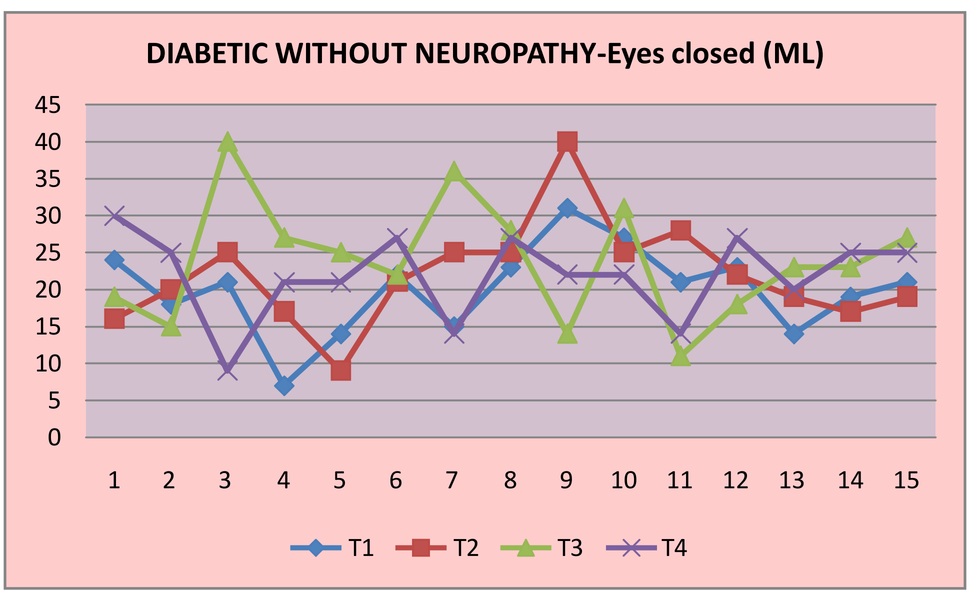
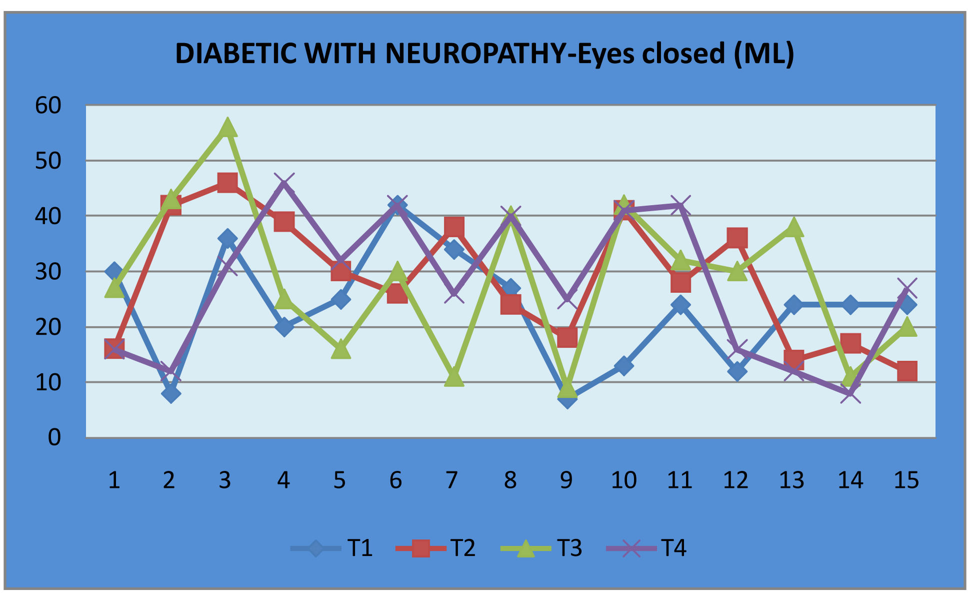


Table 5.2.8: Medial-Lateral sway with Eyes closed condition among Diabetic neuropathy group

Source of variation	Sum of squares (SS)	Degrees of freedom	Mean squares (MS)	Calculated F – ratio	Table F- ratio
Between samples	288.577	3	94.506	0.651	2.70
Within samples	8135.33	56	145.274		
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.8: Medial-Lateral sway with Eyes closed condition among Diabetic neuropathy group



5.3 TWO WAY ANOVA

Table 5.3.9: Eyes open Anterior-posterior sway – TASK Vs GROUP

Source of variation	Sum of squares	Degrees of freedom	Mean square	Calculated F-Ratio	Table F ratio
Between Samples	106.408	1	106.408	2.164	10.13 (1,3)
Between Rows	117.825	3	59.275	1.206	9.28 (3,3)
Residual of Error	5506.66	112	49.167	-	-
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.9: Eyes open Anterior-posterior sway – TASK Vs GROUP

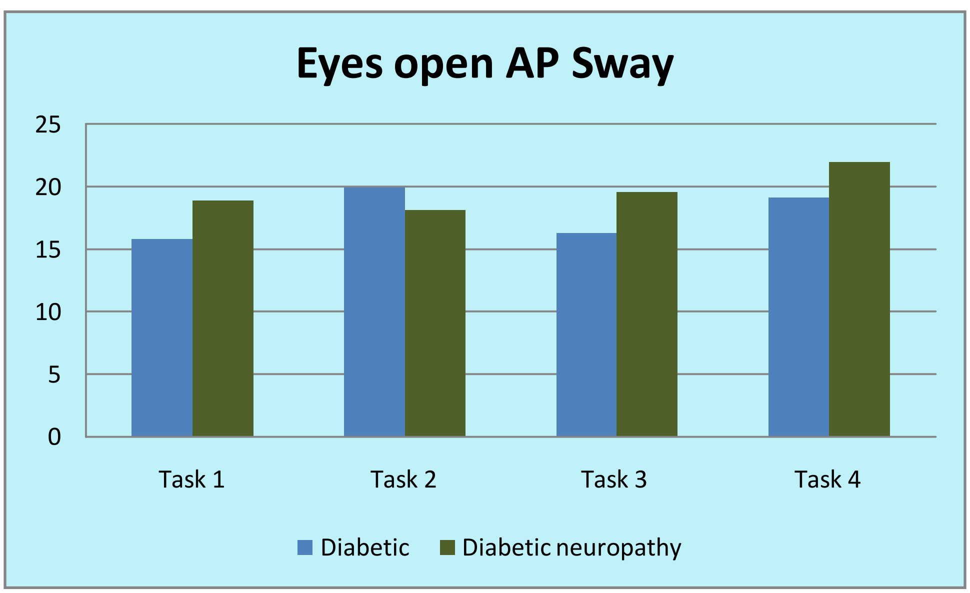


Table 5.3.10: Eyes open Medial-Lateral sway – TASK Vs GROUP

Source of variation	Sum of squares	Degrees of freedom	Mean square	Calculated F-Ratio	Table F ratio
Between Samples	240.833	1	240.833	3.380	10.13 (1,3)
Between Rows	25.100	3	8.367	0.117	9.28 (3,3)
Residual of Error	7980.667	112	71.256	-	-
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.10: Eyes open Medial-Lateral sway – TASK Vs GROUP

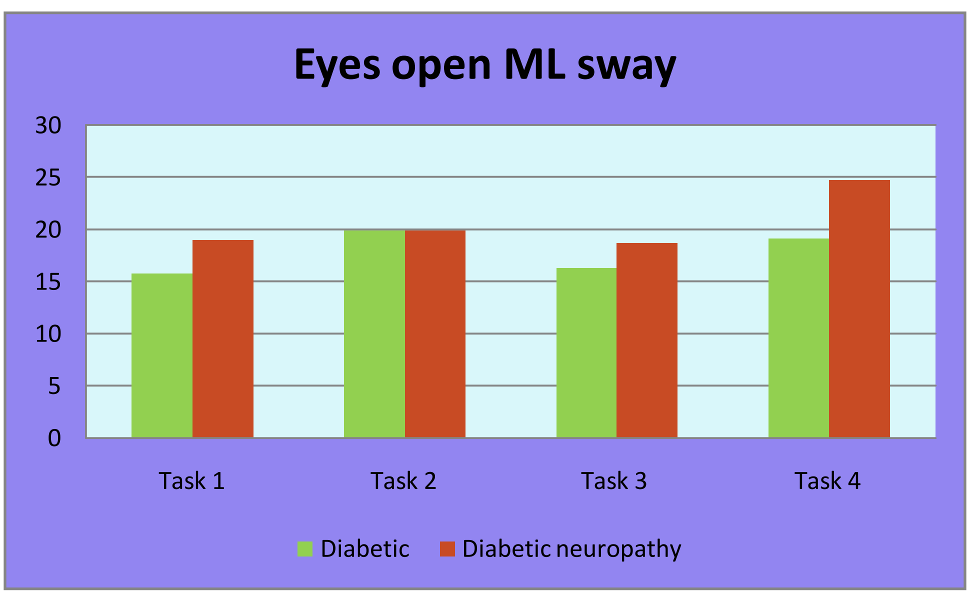


Table 5.3.11: Eyes Closed Anterior-posterior sway – TASK Vs GROUP

Source of variation	Sum of squares	Degrees of freedom	Mean square	Calculated F-Ratio	Table F ratio
Between Samples	238.008	1	238.008	3.035	10.13 (1,3)
Between Rows	426.292	3	142.097	1.812	9.28 (3,3)
Residual of Error	8783.467	113	78.424	-	-
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.11: Eyes Closed Anterior-posterior sway – TASK Vs GROUP

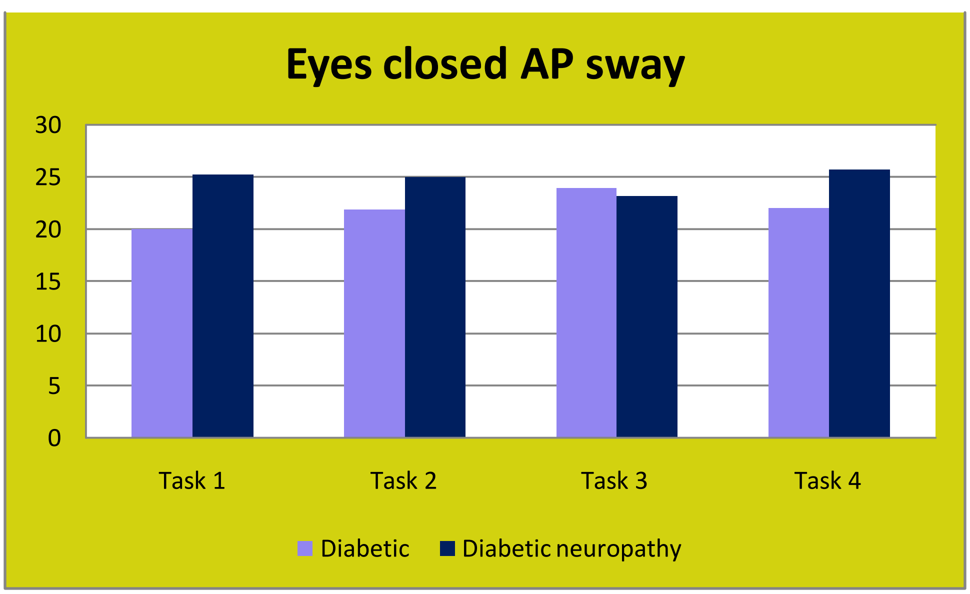
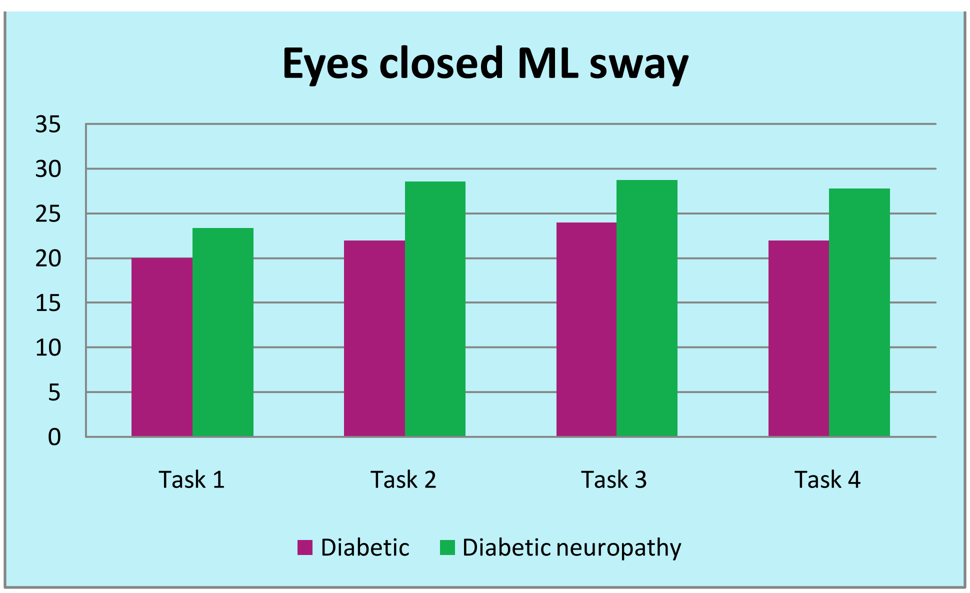


Table 5.3.12: Eyes Closed Medial-Lateral sway – TASK Vs GROUP

Source of variation	Sum of squares	Degrees of freedom	Mean square	Calculated F-Ratio	Table F ratio
Between Samples	785.408	1	785.408	8.251	10.13 (1,3)
Between Rows	354.692	3	118.231	1.242	9.28 (3,3)
Residual of Error	10660.933	112	95.187	-	-
P value & Significance level			P Value > 0.05, Not significant		

Graph 5.12: Eyes Closed Medial-Lateral sway – TASK Vs GROUP



DATA ANALYSIS & RESULTS

6. DATA ANALYSIS & RESULTS

One way ANOVA for Anterior-Posterior sway with eyes open condition among Diabetic without neuropathy Group:

As shown in table 5.2.1, the Anterior-posterior sway measured with eyes open condition among diabetic without neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is 2.70 and the calculated „F‟ value is 1.349.As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic without neuropathy group

One way ANOVA for Anterior-Posterior sway with eyes open condition among Diabetic Neuropathy Group:

As shown in table 5.2.2, the Anterior-posterior sway measured with eyes open among diabetic neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is

2.70 and the calculated „F‟ value is 0.863.As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes open condition among diabetic neuropathy group

One way ANOVA for Medial-Lateral sway with eyes open condition among Diabetic without neuropathy Group:

As shown in table 5.2.3, the Medial-Lateral sway measured with eyes open among diabetic without neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is 2.70 and the calculated „F‟ value is 1.219. As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial-Lateral sway with eyes open condition among diabetic without neuropathy group

One way ANOVA for Medial-Lateral sway with eyes open condition among Diabetic Neuropathy Group:

As shown in table 5.2.4, the Medial-Lateral sway measured with eyes open among diabetic neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is
2.70 and the calculated „F‟ value is 1.142.As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial-Lateral sway with eyes open condition among diabetic neuropathy group

One way ANOVA for Anterior-Posterior sway with eyes closed condition among Diabetic without neuropathy Group:

As shown in table 5.2.5, the Anterior-posterior sway measured with eyes closed among diabetic without neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is 2.70 and the calculated „F‟ value is 0.001. As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes closed condition among diabetic without neuropathy group

One way ANOVA for Anterior-Posterior sway with eyes closed condition among Diabetic Neuropathy Group:

As shown in table 5.2.6, the Anterior-posterior sway measured with eyes open among diabetic neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F‟ value at the level of 5% significance, for 3 and 56 degrees of freedom is
2.70 and the calculated „F‟ value is 0.197.As the table „F‟ value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes closed condition among diabetic neuropathy group

One way ANOVA for Medial-Lateral sway with eyes closed condition among Diabetic without neuropathy Group:

As shown in table 5.2.7, the Medial-Lateral sway measured with eyes closed among diabetic without neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F" value at the level of 5% significance, for 3 and 56 degrees of freedom is 2.70 and the calculated „F" value is 0.858. As the table „F" value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial-Lateral sway with eyes closed condition for diabetic group

One way ANOVA for Medial-Lateral sway with eyes closed condition among Diabetic Neuropathy Group:

As shown in table 5.2.8, the Medial-Lateral sway measured with eyes open among diabetic neuropathy group is analyzed by one way ANOVA to identify the effect of cognitive task on sway. The table „F" value at the level of 5% significance, for 3 and 56 degrees of freedom is 2.70 and the calculated „F" value is 0.65. As the table „F" value is greater than the calculated value, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial- Lateral sway with eyes closed condition among diabetic neuropathy group

Two way ANOVA for Eyes Open Anterior-Posterior sway – TASK Vs GROUP:

As shown in table 5.3.1, the Anterior-posterior sway measured with eyes open for diabetic without neuropathy group and diabetic neuropathy is compared by two way ANOVA to identify the effect of cognitive task on sway between two groups. The table „F" value for between columns at the level of 5% significance, for 1 and 3 degrees of freedom is 10.13 and the calculated „F" value (column) is 2.164. The table „F" value for between rows at the level of 5% significance, for 3 and 3 degrees of freedom is 9.28 and the calculated „F" value (row) is 1.206. As the table „F" value is greater than the calculated value for between columns and between rows, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes open between diabetic without neuropathy and diabetic neuropathy group.

Two way ANOVA for Eyes Open Medial-Lateral sway – TASK Vs GROUP:

As shown in table 5.3.2, the Medial-Lateral sway measured with eyes open for diabetic without neuropathy group and diabetic neuropathy is compared by two way ANOVA to identify the effect of cognitive task on sway between two groups. The table „F" value for between columns at the level of 5% significance, for 1 and 3 degrees of freedom is 10.13 and the calculated „F" value (column) is 3.380. The table „F‟ value for between rows at the level of 5% significance, fo

r 3 and

3 degrees of freedom is 9.28 and the calculated „F‟ value (row) is 0.117. As the table „F‟ value is

greater than the calculated value for between columns and between rows, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial-Lateral sway with eyes open between diabetic without neuropathy and diabetic neuropathy group.

Two way ANOVA for Eyes closed Anterior-Posterior sway – TASK Vs GROUP:

As shown in table 5.3.3, the Anterior-posterior sway measured with eyes closed for diabetic without neuropathy group and diabetic neuropathy is compared by two way ANOVA to identify the effect of cognitive task on sway between two groups. The table „F" value for between columns at the level of 5% significance, for 1 and 3 degrees of freedom is 10.13 and the calculated „F" value (column) is 3.035. The table „F" value for between rows at the level of 5% significance, for 3 and 3 degrees of freedom is 9.28 and the calculated „F" value (row) is 1.812. As the table „F" value is greater than the calculated value for between columns and between rows, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Anterior-posterior sway with eyes closed between diabetic without neuropathy and diabetic neuropathy group.

Two way ANOVA for Eyes closed Medial-Lateral sway – TASK Vs GROUP:

As shown in table 5.3.4, the Medial-Lateral sway measured with eyes closed for diabetic without neuropathy group and diabetic neuropathy is compared by two way ANOVA to identify the effect of cognitive task on sway between two groups. The table „F" value for between columns at the level of 5% significance, for 1 and 3 degrees of freedom is 10.13 and the calculated „F" value (column) is 8.251. The table „F" value for between rows at the level of 5% significance, for 3 and

3 degrees of freedom is 9.28 and the calculated „F" value (row) is 1.242. As the table „F" value is greater than the calculated value for between columns and between rows, the null hypothesis is accepted. Hence there is no significant effect of cognitive task on Medial-Lateral sway with eyes closed between diabetic without neuropathy and diabetic neuropathy group.

DISCUSSION

7. DISCUSSION

Diabetic neuropathy one of the threatening complications of diabetes, has a serious impact on the activity level and the quality of life of the individuals. For the elderly community, it is an extra burden added to the deleterious effects of ageing.

Postural stability of diabetic neuropathic individuals is mainly challenged due to bilateral symmetrical sensory reduction of the lower limbs. The unsteadiness created by the loss of sensory feedback stresses the individual to use much of the attentional components to regulate the postural control. Hence testing with a dual task condition to demand more attention in performing the added task, limits the amount of cognitive processing needed to maintain a posture and also brings out the hidden deficits of asymptomatic individuals. This aids in the early diagnosis and prompt management of abnormal postural control mechanisms.

. This study was done in a need to analyze the effect of simultaneously given cognitive task on the postural sway among diabetic population with and without neuropathy. The subjects were studied on four different levels of cognitive condition which includes no cognitive task, cognitive task I, cognitive task II, cognitive task III. The complexity of the task was further increased by adding eyes open and eyes closed condition to the task. Finally 8 different sway measurements were obtained from each individual for four levels of cognitive tasks in eyes open and closed conditions. After the assessment, sway measurements were interpreted and maximum Anterior- posterior and Medial- Lateral sway values in mm for each task were calculated manually.

The data was analyzed statistically with one and two way ANOVA to detect the effect of the cognitive task on sway. Within the diabetic without neuropathy group the Anterior-posterior and Medial-Lateral sway values were analyzed to identify the difference between the 4 tasks in eyes open and eyes closed conditions. But, there was no much difference of the sway change for all 4 types of the tasks. The same analysis was repeated in diabetic neuropathic group in eyes open and eyes closed conditions. Despite of mild changes, the sway measurements of diabetic neuropathic group didn‟ t show any significant difference between the tasks.

This indicates that the effect produced on postural sway by standing with no task was more or less similar to that of the 3 cognitive tasks. This similarity explains the lack of sufficient dual task interference or decremented response in postural control mechanism to induce a change in the sway. The postural swaying didn‟ t increase with the concurrent performance of a cognitive task while maintaining the standing posture as expected.

The cognitive tasks administered failed to stress the cognitive processing abilities of the individual to the needed extent. Dividing the attention between the task had less cross talk effect. This would be the reason for the individuals to demonstrate only mild sway changes in the presence of cognitive tasks.

Oliver Huxhold et al.,(2006) supported the U-shaped relationship of attentional demanding tasks and postural sway which denotes the level of arousal produced by the secondary cognitive task based on **Yerkes–Dodson law.** [31] The law states that "low level cognitive processing increases the arousal level in a way that triggers postural regulatory adjustments, whereas high cognitive load leads to higher arousal level and suboptimal processing causes decrement in performance".

The individuals were given prior instruction about the assessment and cognitive tasks given during the measurement. This might have also increased the anxiousness and the arousal level of the individual. The presence of the participants in the new environment might have also induced the aroused state. These reasons would have contributed to the lack of significant difference between the levels of concurrent cognitive task.

The sway measured was also analyzed to compare the effect of cognitive tasks between diabetic without neuropathy and diabetic neuropathic group. Even though mean differences existed between diabetic without neuropathy **(**Anterior-posterior **=19.8±7.2,** Medial-Lateral **=19.8±7.23)** and diabetic neuropathy group **(**Anterior-posterior **=22.1±8.73,** Medial-Lateral **=23.8±11.5),** it failed to elicit a statistically significant output. The subjects also showed mean difference in eyes open **(**Anterior-posterior **= 18.67±7,** Medial-Lateral **=19.41±8.9)** and eyes closed **(**Anterior-posterior **= 23.35 ± 8.3,** Medial-Lateral **= 24.49±9.9)** irrespective of the group they belonged. All four levels of task failed to demonstrate a difference between the diabetic without neuropathy and diabetic neuropathy group.

According to **Elado Martin et al., (2011)**[10], the difficulty level of the task and the skill level of the individual may have a significant impact on the amount of attention demandend by the task. The skill level of the individuals may interfere in performing the given cognitive task. The same cognitive task may demand high level of mental processing in few individuals where as a low level of processing in the rest. This would have been a reason for the failure of cognitive task to produce significant difference on the sway. Hence for the difficult task, the individual may be more aroused and the differences might not be elicited.

According to **Jolene Feldman.,(2007),** analyzed the effect of blood glucose level on various parameters. The high and low levels of blood glucose at the time of measurement might affect both the cognitive processing and postural stability skills of the individual. Immediately after the load of glucose, the performance of attention demanding deteriorates.[14] Hence the role of blood glucose has to be considered in future studies. The future studies can incorporate the checking of blood glucose level with portable glucometer before assessing the sway.

The studies with homogenous population of similar age group and same gender, Body mass index are needed to examine the effectiveness of the cognitive task on postural. The concurrent cognitive task used in the study resembles the arithmetic calculations and it was much different from that of activities of daily living. Further research can be done with cognitive tasks mimicking the common tasks of daily living.

SUMMARY & CONCLUSION

8. SUMMARY AND CONCLUSION

The study was done with an aim to study the effect of concurrent cognitive task on postural sway among diabetic without neuropathy and diabetic neuropathy group. In this study, the performance of cognitive task in standing was not much differentiated from standing only task in inducing postural sway. Also the concurrent application of cognitive tasks on standing, showed very little effect on the postural sway between diabetic without neuropathy and diabetic neuropathy group. Dual task assessment being one of the extensively researched topics, its application in unhealthy individuals has to be further explored considering the pathological process of the existing disease.

Dual task assessments at different stages of a progressing disease like diabetic neuropathy will give a clear picture about the amount the attention needed to maintain the posture for a particular stage of disease. Based on the amount of attention demanded to maintain a posture, the point of commencement of dual task training and the intensity of training can be decided. This will help to improve the quality of life of the individuals by reducing the risk of falls in dual tasking condition.

LIMITATIONS & SUGGESTIONS

9. LIMITATIONS AND SUGGESTIONS

Limitations:

- Measurements are taken in single trial for each task
- Lack of Structured environment with sound proof ambience
- Hypo or hyperglycemic status of the individual is not considered in the individual while measuring the sway
- Cognitive tasks are standardized for all individuals. Cognitive task should be given by considering the skill level of the individual
- Sample size was small
- The study was not single or double blinded
- Effects of fatigue on sway are not considered

Suggestions:

- Complexity can be added by measuring in foam surface
- Two or three trials of sway measurements are suggested for future studies
- Homogenous sample including single age group and gender may help to determine the extraneous factors affecting sway
- Interventions like facilitation of hand and feet can studied in order to control minimize sway in excess swaying individuals
- Video analysis can be preferred
- Can be compared with healthy control subjects
- Digital pen can be used in future studies to measure sway which may add to the accuracy of the instrument
- Quantitative methods of sway measurements like force platform can be employed in the study

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APPENDICES

APPENDIX I

INFORMED CONSENT TO PARTICIPATE IN THE RESEARCH STUDY

I ______________voluntarily accept to participate in the research study titled "**Effect of Concurrent Cognitive Task on Postural Sway in Type-2 Diabetic Individuals with and without Sensorimotor Polyneuropathy"**

The researcher has explained me about the research in brief, the risk of participation and has answered the questions related to the research to my satisfaction.

Signature of the applicant:

Signature of the researcher:

Signature of the witness:

APPENDIX -II

Name: **Age\Gender:** **IP\OP No:**

Height: **Weight:** **BMI:**

Occupation: **Address:**

Relevant past medical history:

Known diabetic for ---------- years

Fasting plasma glucose level:

Control of diabetes: Controlled or uncontrolled

Drug history:

History of fall:

- **Due to trip**
- **loss of balance**
- **leg giving way**
- **Any functional limitations due to fear of falling**

History of dizziness: Yes\No

- **A sensation of movement of yourself or the room: spinning, tilting, or wave-like movement**
- **Lightheadedness or feeling that you are going to faint**
- **Loss of balance**
- **Disassociation or disorientation with the world**

If yes Dix Hall Pike test: positive/negative

Foot Ulcer: present or absent

Peripheral pulses:

Associated problems:

Visual acuity:

Mini cog:

-Immediate word repeating

-Clock drawing test

-Recalling words:

-Final Score:

Michigan Neuropathy Screening Score:

Limits of stability:

		Ant-post	Med-lat
Eyes Open	Standing		
	Cog Task I		
	Cog Task II		
	Cog Task III		
Eyes Closed	Standing		
	Cog Task I		
	Cog Task II		
	CogTask III		

APPENDIX - III

MICHIGAN NEUROPATHY SCREENING INSTRUMENT

Physical Assessment (To be completed by health professional)

1. Appearance of Feet

	Right		Left	
a. Normal	☐ 0 Yes	☐ 1 No	☐ 0 Yes	☐ 1 No
b. If no, check all that apply:				
Deformities	☐		☐	
Dry skin, callus	☐		☐	
Infection	☐		☐	
Fissure	☐		☐	
Other	☐		☐	
specify:	________		________	

	Right: Absent	Right: Present	Left: Absent	Left: Present
Ulceration	☐ 0	☐ 1	☐ 0	☐ 1

	Right: Present	Right: Present/ Reinforcement	Right: Absent	Left: Present	Left: Present/ Reinforcement	Left: Absent
Ankle Reflexes	☐ 0	☐ 0.5	☐ 1	☐ 0	☐ 0.5	☐ 1

	Right: Present	Right: Decreased	Right: Absent	Left: Present	Left: Decreased	Left: Absent
Vibration perception at great toe	☐ 0	☐ 0.5	☐ 1	☐ 0	☐ 0.5	☐ 1

	Right: Normal	Right: Reduced	Right: Absent	Left: Normal	Left: Reduced	Left: Absent
Monofilament	☐ 0	☐ 0.5	☐ 1	☐ 0	☐ 0.5	☐ 1